Space Weather Technical Forecast

Issued on Monday, 27 December 2021 at 00:53 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of Active electron fluence. Chance of G1/Minor Geomagnetic storm, peaking Tuesday 27 December.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with occasional C-class X-ray flares observed at GOES 16 in the period. The largest of these flares reached C3.3 at 26/2012UTC, and appeared to be tied to a possible filament eruption from the environs of AR2920. Also of note was a marginally earlier and smaller magnitude flare, in the form of a C1.4 at 26/1859UTC, which emanated from Ex-2907 over the southwestern solar horizon.

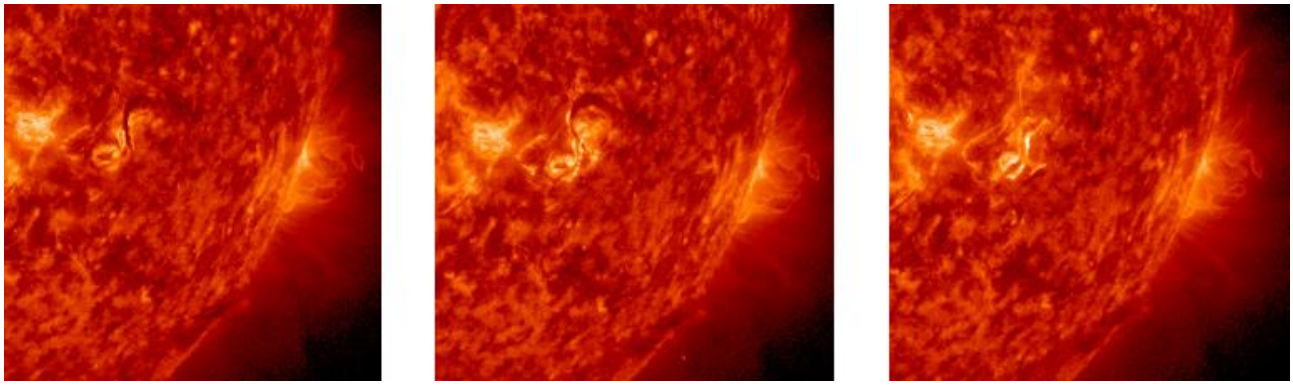

Figure 0: AIA 304 imagery sequence spanning 26/2020-2036UTC, showing the southwest quadrant filament eruption. This feature has yet to be assessed for any ICME.

There are now up to six sunspot regions on the solar disc, including a possible developing unnumbered region in the northwest quadrant that appeared to reach Bxo/Beta classification by the period's end. The disc is dominated areally and in terms of complexity by two large sunspot groups - firstly AR2916 in the southeast, which was assessed as an Ehc/Beta with a slow spreading tendency and slight areal decay. Of potentially more note was the smaller but more dynamic AR2918 in the northern solar hemisphere, with proliferation in its intermediate spots and a Eai/Beta classification. These groups were joined by several other more minor groups, of which AR2920 was perhaps the most significant for its growth trend to reach Bxi/Beta. AR2912 and 2919 were both unipolar and stable at Axx/Alpha and Hrx/Alpha respectively.

A large filament eruption was observed in the southwestern quadrant between 26/0200-0300UTC, with some evidence of ejecta on recent Lasco and STEREO A COR2 coronagraph imagery. This event has been analysed and appears to both lead and lie below the Earth in its orbit to no anticipated effect. This event was joined late in the period by the aforementioned smaller filament eruption tied to the largest flare of the 24 hours, although at the time of writing imagery is not yet available. No confirmed Earth-directed Coronal Mass Ejections (CMEs) were in evidence, with one event to be assessed.

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Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, declined to a slow solar wind regime in the period, with the speed falling from around 425km/s to reach 325km/s. The solar wind density was stable and near background in mid-single figures ppcc, while the IMF was unremarkable below 4nT, with a north-south component between +/-3nT. The phi angle underwent a change from mostly negative (towards the sun) prior to 26/1300UTC and after 26/2200UTC, with an intervening period of positive.

The net effect of the preceding solar wind measures was provisionally Quiet throughout, with a peak Kp of 1+ in the 18-21UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels.

The high energy electron flux (greater than 2 MeV) reached High levels between 26/1100UTC and 2120UTC, peaking at 2080pfu at 26/1630UTC. The associated 24-hour integrated fluence reacted upwards through the 24-hour period towards but remaining below the 1e8 Active threshold. At 27/0000UTC the observed fluence was 8.51e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low solar activity is forecast throughout the period, but with a daily Chance of M-class flares. No significant regions leave the disc in the period, although some contribution is expected from Ex-2907 at first, narrowly over the western limb. No significant returning regions are expected.

Solar Wind / Geomagnetic Activity: There are two potentially Earth-directed CMEs forecast, however both are currently expected to miss, with only weak glancing impacts at most at the very start of the four-day period. There is otherwise one unassessed candidate filament eruption CME from the southwestern quadrant, emitted 26/2012UTC. No other CMEs feature in the forecast.

Earth is currently sampling a slow solar wind environment and experiencing Quiet geomagnetic activity. There is a Slight Chance of G1 should either of the 21 or 22 December CMEs deliver a glancing blow at the very start of the period, with this G1 risk increasing with the expected arrival of CH39 on day two, Tuesday 27 December. This risk should wane midweek, rounding out the period with a gradual return to Quiet Kp.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels with a daily Slight Chance of S1 should there be any significant flare activity.

High energy electron flux (greater than 2MeV) levels are now expected to be higher in the period, with a Chance of breaching Active on days one and two (Monday 27 and Tuesday 28 December). There should then be a hiatus on onset of CH39 through midweek, perhaps recovering slightly by the end of the four days.

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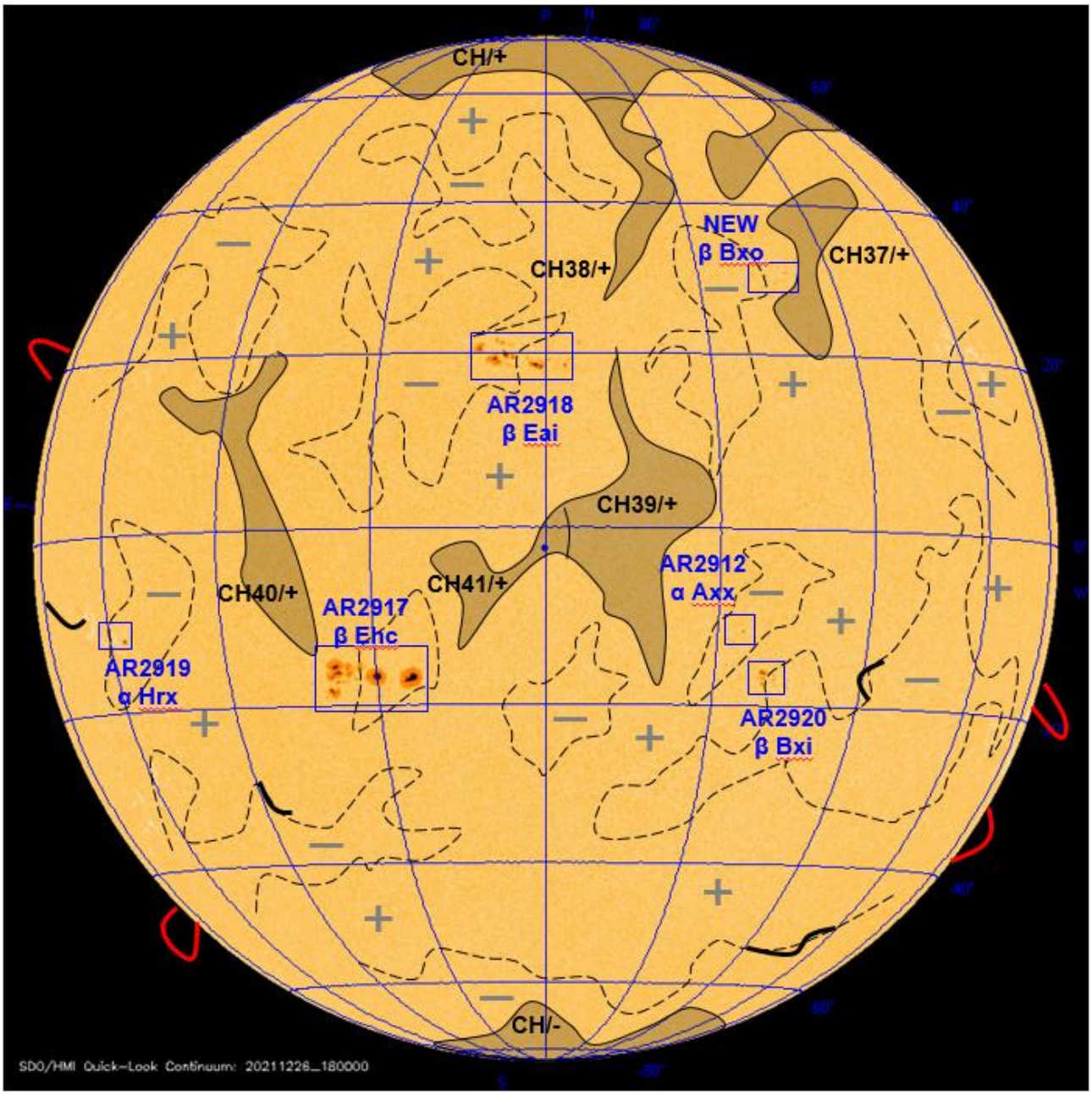
Figure 1. Solar Analysis Valid 26/1800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two CMEs of current interest for the period, which left the Sun on 21 and 22 December respectively. These may glance the Earth on 26 or 27 December, giving perhaps a Slight Chance of G1 on day one, Monday 27 December (5%). However, as both were relatively narrow features, there is low confidence in this aspect of the forecast and they could miss entirely. There is otherwise one unassessed candidate CME from a filament eruption on 26/2012UTC, with this feature pending imagery for analysis. No other CMEs feature in the forecast.

Earth is currently sampling a slow solar wind environment. The latest STEREO A MAG and PLASTIC data suggest a high speed stream has been affecting the satellite since the start of the UTC day of 26 December, which implies a positive polarity high speed stream of the order of 500km/s arriving at Earth on 28 December (given the 2.7-day lag). This is probably the fast wind emanating from CH39, with CH37 and 38 perhaps too far pole-ward to feature. This may form a more lasting fast wind feature than previously anticipated, for having apparently merged with succeeding CH41 to its east to form a greater span across centre-disc. This coronal hole is not a persistent feature, and as such confidence in expected geomagnetic activity is low, but a Chance of G1 is proposed, the risk probably peaking with onset later on day two, Tuesday 28 December. A tailing off of this risk is forecast for the middle of the UTC week, with Quiet geomagnetic activity having resumed to end the four days.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	5	30	5	1
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
22/12/2021 1735UTC	N/A	AR2908	SE	475km/s	Within day one.	Probable miss
22/12/0726UTC	N/A	Uncertain	N/A	319km/s	Within day one.	Probable miss

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Radio Blackouts - X-Ray Flares:

Solar Activity has been Low, with several small C-flares. Background X-ray flux recorded at GOES 16 showed an overall slight decline in the 24 hours of 26 December, perhaps in part because of the departure of Ex-2907 over the southwestern horizon, although it remains theoretically capable of affecting Earth - should it produce any large flares. This is the reason for the slightly higher risks on day one, Monday 27 December relative to the remainder of the period. The disappearance of this region and the lack of compensatory returning regions in the period should mean an overall reduction in risk relative to the Christmas period.

The current Earth-facing disc is dominated areally by 2916 and 2918, although neither of these regions has delivered the full scope of their class, being Ehc/Beta and Eai/Beta respectively. This may be because they are now mature, and neither has shown any appreciable growth in recent hours.

C-class flares remain Expected through the four days, with a daily Chance of M-class flares, all largely because of the two largest regions on the disc, and falling slightly after day one as Ex-2907 passes beyond reach onto the far side.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	No	30	25	25	25
Very Active	**R3 to R5 X Class**	No	5	1	1	1

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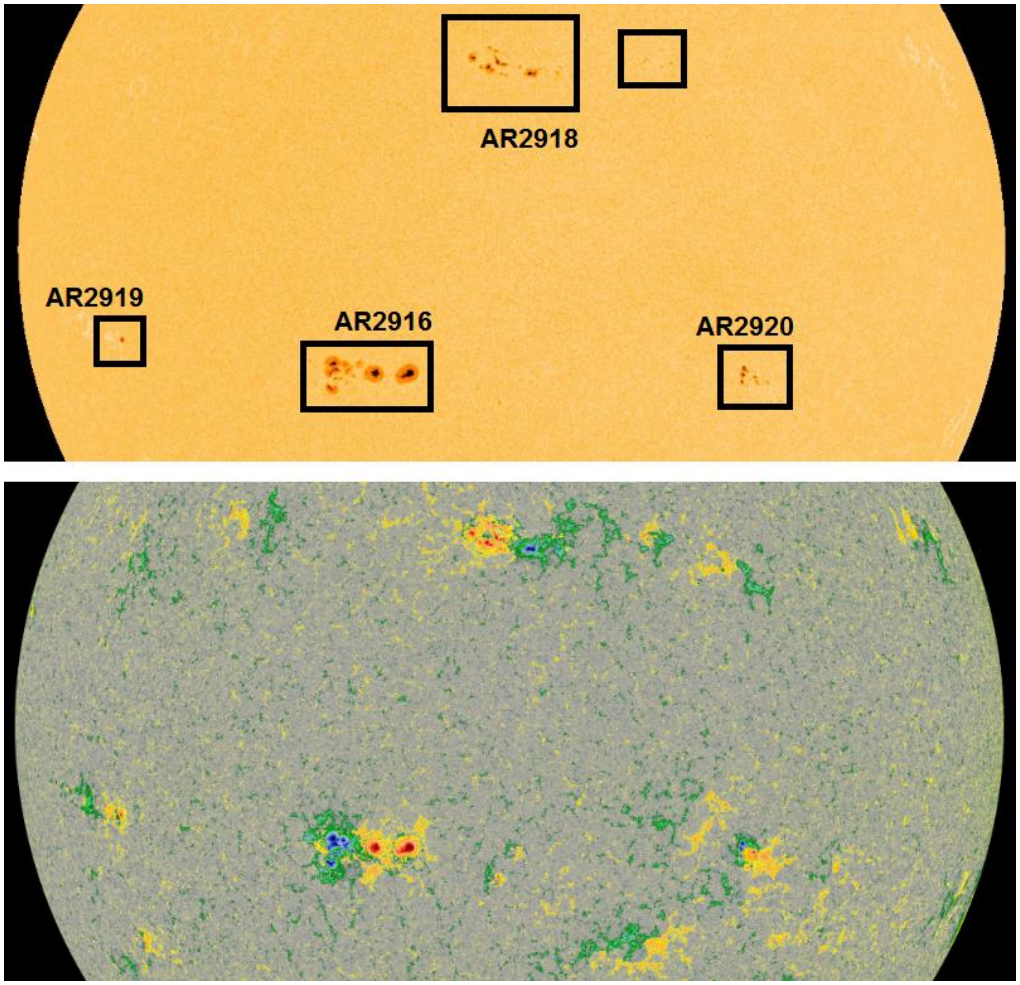
Figure 3: Sunspot regions on the Earth-facing disc at 26/2400UTC.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at Background levels and will most likely persist as such. There is a Slight Chance of S1 from any notable flares on the disc, perhaps most likely from AR2916 or AR2918 on paper, with this contribution also bolstered by AR2907, despite this final region now being beyond the western limb.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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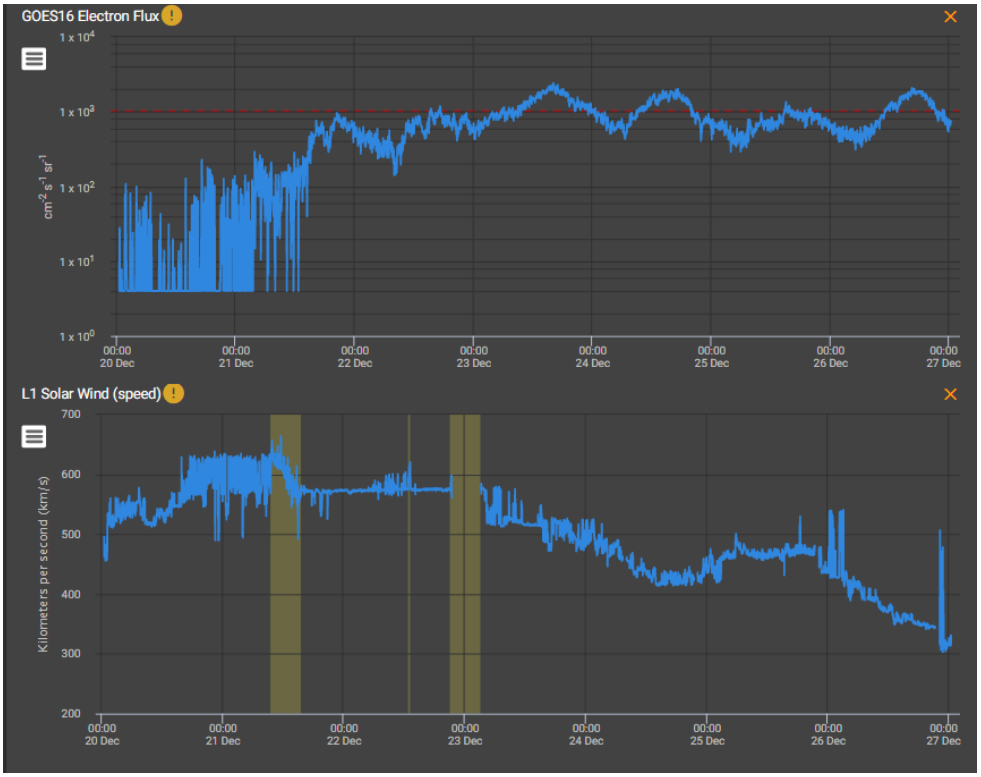
High Energy Electrons Event (≥ 2MeV):

The diurnal oscillation in high energy (greater than 2MeV) electron flux, as observed by GOES-16 showed a slight increase relative to Christmas Day (UTC), perhaps a return to the effects of the earlier 600km/s high speed stream, once the interruption of the most recent 475km/s feature waned.

Whatever the mechanism, the chances of Active electron fluence being realised are now substantially higher than in recent guidance, albeit with only minor exceedence of 1e8 fluence expected. The onset of CH39/+ on day two, Tuesday 27 December ought to further interrupt this trend, probably recovering to a degree by the very end of the period, but perhaps to a lower level.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	40	40	10	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: The past week in high energy electron flux at GOES 16 (and below, solar wind speed at L1), showing a response to the initial 600km/s high speed stream, perhaps briefly 'dented' by geomagnetic activity from the smaller succeeding 475km/s high speed stream. This may be the reason for levels appearing to revert to their earlier oscillation in recent hours.



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